Improving the diagnostic capabilities for detecting molybdenum deficiency in alfalfa and avoiding toxic concentrations for animals

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Objectives

1). To characterize the relationship between plant tissue molybdenum and copper concentrations and alfalfa yield response where molybdenum is applied at several rates.

2). To develop a broader ranged diagnostic capability by assessing plant tissue molybdenum concentrations at different stages of alfalfa growth where several rates of molybdenum have been applied.

3). To provide standard forage samples for distribution to analytical laboratories by collecting large quantities (20-50 lbs) of two alfalfa samples having molybdenum concentrations in the range of 0.1-0.3 ppm and 0.5-0.7 ppm.

Results and Discussion

Two sites have been established, one in Shasta County several miles north of Burney, CA, (Site or experiment #1) and a second in Siskiyou County several miles west of Fort Jones, CA, in Scotts Valley (Site or experiment #2). The Shasta County Site was initiated on March 31, 2000 when the treatments listed in Table 1 were applied. Individual plots were 10 ft by 25 ft in size and the field trial design was a randomized complete block with 3 blocks or replications. Several alfalfa fields on the ranch were sampled in August 1999 and indicated top 1/3 of plant concentrations of molybdenum were in the 0.1 – 0.3 ppm range. Plant tissue samples also indicated that phosphorus, potassium, sulfur, and boron were in the adequate range.

Yield results from site 1 (experiment #1) for 2002 are given in Table 1. In both the first and second harvests (June 14th and July 19th) there were significant yield responses to molybdenum treatments. This is similar to the yield responses for

previous years given in last year's report. Note as well that the lime alone treatment resulted in equally as high a yield as the molybdenum treatments. This is often the case since raising the soil pH increases the availability of molybdenum to plants. Maximum yield was often achieved with as little as 0.2 lbs Mo/A up to the higher rates of 0.8 lbs Mo/A. Rates greater than 0.6 – 0.8 lbs Mo/A however usually increased molybdenum concentrations in the forage to undesirable levels considering the needs of animals, particularly if copper concentrations are below the 8 – 10 ppm range. Phosphorus (PO_4-P), potassium, sulfate-sulfur (SO_4-S) and boron were all in the adequate range.

Table 1. Alfalfa yield during 2002 as influenced by molybdenum and lime treatments applied on March 31, 2000.

Treatment	Mo (lbs/A)	Lime (tons/A)	June 14 Yield (tons DM/A)	July 19 Yield (tons DM/A)	Sept 3 Yield (tons DM/A)
1. Control	0	0	1.81 b	1.48 cd	1.52
2. Mo	0.2	0	1.94ab	1.45 cd	1.65
3. Mo	0.3	0	1.93ab	1.57abc	1.59
4. Mo	0.4	0	1.95ab	1.41 d	1.58
5. Mo	0.6	0	1.91ab	1.63ab	1.49
6. Mo	0.8	0	2.07ab	1.68a	1.66
7. Mo	1.2	0	1.83ab	1.51 bcd	1.50
8. Lime	0	2	2.22a	1.57abc	1.62
$LSD_{0.05}$			0.396	0.124	NS(0.200)

Plant growth stage samples were taken at 6 inches height, 12 inches height, prebud (only a small ball was formed to indicate the new bud) and at harvest (early bud to $1/10^{th}$ bloom) for the first harvest only in 2002. A herbicide treatment was applied after the third plant sampling which severely stunted the alfalfa growth and delayed the harvest about 3 weeks. All of the plant material of the samples collected at the 6-inch growth stage and only the top 6 inches of the 12-inch high or older plants were analyzed for molybdenum concentrations to develop the relationships between growth stage and molybdenum concentration. Figure 1 shows the rather uniform molybdenum concentration in the top 6 inches or top 1/3 of the plant samples for the growth of the first harvest for 2001. This is particularly true for plant concentrations of less than 1 ppm, which is the normal range for alfalfa plant deficiencies. For diagnostic purposes, this is particularly helpful since plant samples could be taken anytime during the growth of the crop, not just at a defined stage of growth such as $1/10^{th}$ bloom stage. The plant growth stage samples, as well as the harvest plant part samples for the current year, are being processed for laboratory analyses.

The Siskiyou County site (Experiment #2) was initiated when the treatments given in Table 2 were applied, lime on March 9, 2001 and boron and molybdenum on

March 10, 2001. Individual plots were 10 ft by 25 ft in size and the field trial design was a randomized complete block with 3 blocks or replications. The alfalfa field proposed for a trial was sampled on June 21, 2000 and found to have low concentrations of molybdenum (0.2 – 0.3 ppm) and boron (6 ppm). Plant tissue samples also indicated that phosphorus (>2700 ppm midstem PO_4-P), potassium (>4.5 % midstem total K), and sulfate-sulfur (>1250 ppm midstem leaf SO_4-S) were in the above adequate range.

Yield results of the four harvests from site 2 (experiment #2) for 2002 are given in Table 2. Selected treatments resulted in significantly higher yields over the control in the first three harvests. It can be noted that neither molybdenum, boron nor lime alone resulted in as consistently high yields as when at least molybdenum and boron were applied. As was observed in experiment 1, near maximum yield was often achieved with as little as 0.2 lbs Mo/A. Observations of the trial just prior to harvest (all four harvests) indicated the control plots, as well as those receiving molybdenum alone, had slightly chlorotic tops of the plants because of boron deficiency. This slightly chlorotic appearance of the tops of the plants caused by boron deficiency seldom results in large vegetative yield decreases but could reduce seed yields by 25 to 50% or more.

Table 2. Alfalfa yield during 2002 as influenced by molybdenum, boron and lime treatments
applied on March 9-10, 2001.

Treatment	Mo (lbs/ A)	B (lbs/ A)	Lime (tons /A)	May 28 Yield (tons DM/A)	July 3 Yield (tons DM/A	Aug 8 Yield (tons DM/A	Sept 20 Yield* (tons DM/A
1. Control	0		0	1.83	1.80	1.90	1.30
2. Mo plus B	0.2	4	0	2.09	2.22	2.16	1.44
3. Mo plus B	0.3	4	0	2.16	2.26	2.04	1.39
4. Mo plus B	0.4	4	0	2.24	2.12	2.07	1.36
5. Mo plus B	0.6	4	0	2.24	2.13	2.09	1.41
6. Mo plus B	0.8	4	0	2.08	2.22	1.94	1.35
7. Mo plus B	1.2	4	0	2.12	2.20	2.09	1.40
8. Mo	0.4	0	0	1.88	1.88	1.87	1.29
9. Mo	0.8	0	0	1.96	1.89	1.96	1.31
10. B	0	2	0	2.11	2.00	1.95	1.27
11. B	0	4	0	2.14	2.10	1.99	1.35
12. Lime	0		2	1.85	1.99	1.97	1.29
13. Mo + B + Lime	0.2	4	2	2.21	1.97	2.00	1.39
14. Mo + B + Lime	0.4	4	2	2.20	2.08	1.91	1.31
$LSD_{0.05}$				0.271	0.276	0.225	0.159

*Estimated at 20% dry matter.

Plant growth stage samples were taken at 6 inches height, 12 inches height, prebud and at harvest (early bud to 1/10th bloom) prior to the first and third harvests in 2002. In some cases the growers will be harvesting prior to 1/10 bloom so samples taken at harvest will be characterized as to stage of growth. All of the plant material of the samples collected at the 6-inch growth stage and only the top 6 inches of the 12-inch high or older plants were analyzed for molybdenum concentrations to develop the relationships between growth stage and molybdenum concentration. Figure 2 shows the somewhat uniform molybdenum concentration in the top 6 inches or top 1/3 of the plant samples for the growth of the first harvest for 2001. This is particularly true for plant concentrations of slightly above or less than 1 ppm, which is the normal range for alfalfa plant deficiencies. As this was also the case in Experiment #1, it becomes particularly desirable for diagnostic purposes since plants samples could be taken anytime during the growth of the crop, not just at a defined stage of growth such as 1/10th bloom stage. The plant growth stage samples as well as the harvest plant part samples for the current year are being processed or have been submitted to the laboratory for analyses.

All of the plant material collected for analysis is being saved for the preparation of several large bulk samples of known molybdenum concentration. After the analyses have been completed, samples having similar molybdenum concentrations will be combined in the range of 0.1-0.3 ppm or 0.5-0.7 ppm. These two standard forage samples are being prepared for distribution to analytical laboratories.

Figure 1. Alfalfa molybdenum concentrations during May 2001 as influenced by applied treatments. Expt #1

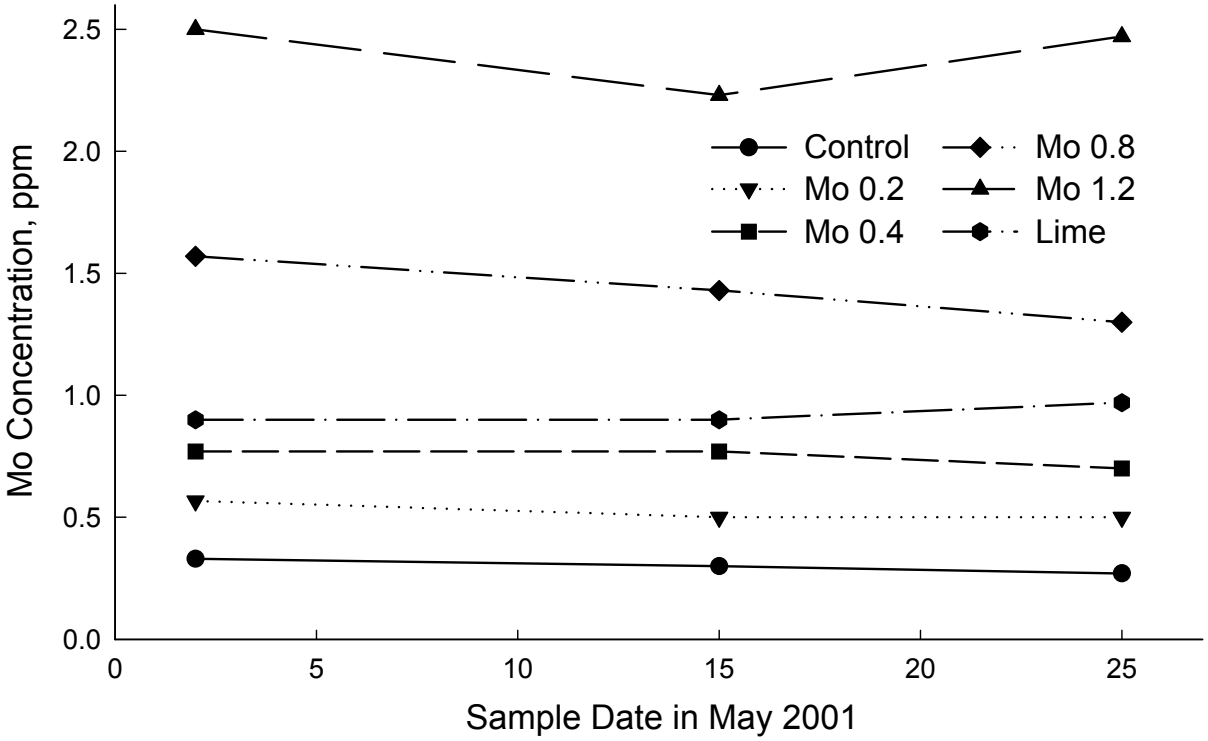

Figure 2. Alfalfa molybdenum concentrations during early May 2001 as influenced by applied treatments. Expt #2